The Application of a Bulk Acoustic Wave Sensor for Pesticide Detection in Liquids

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The widespread use of pesticides on commercial food crops can result in short and long term health problems for both farm workers and consumers as well as serious impacts on the environment. Consequently, there is an increasing need to develop low cost portable detection systems that can be used to screen for pesticide residues on food products. One particular pesticide that is routinely used is phosmet ($C_{11}H_{12}NO_4PS_2$). Currently gas chromatography/mass spectrometry (GC/MS), which is a lab-based instrument and requires a very complex pre-treating process, is used in the detection of phosmet. Phosmet is however difficult to detect in the gas phase because of its very low room temperature vapor pressures, 0.065MPa. In addition it is thermally unstable, decomposing rapidly above 65 ^oC. In the present study, a novel sensor based on a polymer coated quartz crystal microbalance (QCM) has been developed to detect phosmet in the liquid phase.

A commercial 5MHz AT-cut QCM (Maxtek, Inc. model number 149211-1) has been used as the sensing platform. The QCM sensing surface was coated with a film of polyepichlorohydrin (PECH) dissolved in chloroform. A typical frequency shift obtained after evaporation of the solvent was 2.5KHz. The crystal was then submerged in a water bath maintained at room temperature. 50.3mg of analytical phosmet dissolved in 2 ml of methanol is used as testing sample and injected into the water bath.

Fig.1 shows changes in the resonant frequency of the PECH coated QCM following 2-10 micro liters of phosmet injections into the water bath containing 66 ml of water. The turnaround in the frequency shift at approximately 300 minutes is due to the saturation of the water bath with phosmet. This is verified by the documented solubility limit of phosmet in water of 25mg/l. Fig.2 shows the frequency shift as a function of the amount of phosmet injected into the water. The resolution of this system is 0.1Hz. The frequency shift of the QCM is 15Hz, when a 2 micro liter testing sample was injected into 66 ml of water where the equivalent concentration is about 1ppm. It indicates that the sensitivity of this sensor is measured to be 15Hz/ppm. The response mechanism between PECH and phosmet is most likely a hydrogen bonding interaction. This is due to the fact that the phosmet is an organophosphorous pesticide and its OCH_3 parts have strong hydrogen bond basic properties and PECH has moderate hydrogen bond acidic properties. [1]

When the saturated sensor was put back into pure water, the frequency increased back to its original baseline, which indicates that the phosmet absorbed by PECH can be removed through flushing. A subsequent exposure to phosmet solution produced a similar response curve with a reproducibility of less than 2% from that shown in Figure.2.

In conclusion, the PECH coated QCM displays a linear response to phosmet injections up to 55 micro liters. Factoring in the system resolution, the lowest limit of detection is projected to be in the sub ppm range.

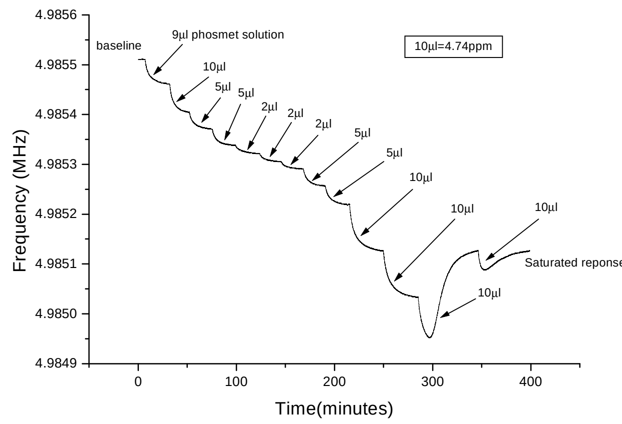

Fig.1 Changes in resonant frequency of the PECH coated QCM following a series of phosmet injections to the water bath**.**

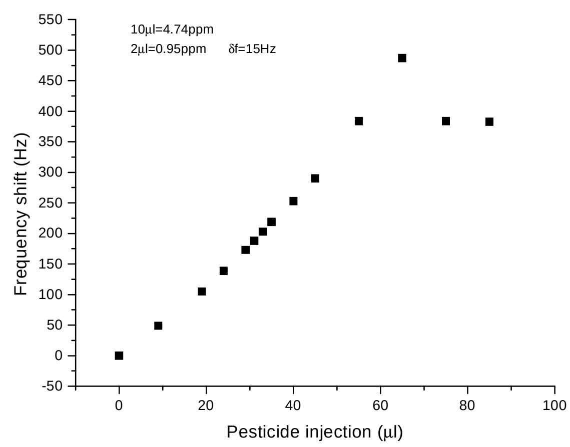

Fig.2 The net frequency shift as a function of phosmet injections from the data of figure 1.

Reference:

[1] R.Andrew McGill, Michael H. Abraham, Jay W. Grate, Choosing polymer coatings for chemical sensors, Chemtech, p.27, September 1994.